I-RIM

PhD Course in

ROBOTICS AND INTELLIGENT MACHINES

Curriculum: Robotics and Intelligent Machines for Inspection and Maintenance of Infrastructure

Research themes

The main goal of the Robotics and Intelligent Machines Inspection and Maintenance of Infrastructures curriculum is to train scientists and researchers capable of working in multidisciplinary teams on topics related to state-of-the-art solutions for Inspection and Maintenance of Infrastructures tasks. Robotics has a high potential in the technological innovation process of inspection and maintenance processes to reduce costs, improve the quality of services, as well as safety and environmental impact. The impossibility of adapting existing plants and infrastructures to the capabilities of common industrial robots, combined with the growing autonomy of the most advanced technological solutions, has created the right conditions for the development of specific service robotics solutions for civil and industrial inspection and maintenance applications.

The 4 scholarships offered in the second call of this year by Università degli Studi di Genova and Italian Institute of Technology as part of this curriculum will be assigned to the best applicants to each of the 4 themes offered.

Theme 1 deals with the use of unmanned aerial vehicles to perform industrial inspections operations, such as, for example, the inspection of photovoltaic and wind installations.

Theme 2 will explore the use of marine robots for the inspection and maintenance operations of underwater infrastructures.

[1] (*) This grant is co-funded by Regione Liguria.

Theme 3 aims to develop control and interaction components for the robot involving perception-driven mobility and manipulation in constrained spaces, like corridors and corners, while collaborating with humans in transporting objects.
Theme 4 will be developed and evaluated in simulation and finally implemented and validated on the CENTAURO prototype and the under-development new quadrupedal manipulation platform of the HHCM lab.

International applicants are encouraged and will receive logistic support with visa issues, relocation, etc.

1. Autonomous multirotor aerial drones for the inspection of industrial facilities – JPDroni s.p.a. and Università di Genova (*)

Curriculum: Robots and Intelligent Machines for Inspection and Maintenance of Infrastructures

Hosting Institution

University of Genova

Department:

DIBRIS, Department of Informatics, Bioengineering, Robotics and Systems Engineering

Tutor(s):

Prof. Antonio Sgorbissa (UNIGE)
Mr. Jacopo Calla (JPDRONI)

Description:

The research activity will address various topics related to the use of aerial drones for industrial inspection. Starting from an analysis of the international literature in this field, some case studies will be selected among those of particular interest internationally and on which the company carries out research and development activities, such as the inspection of photovoltaic and wind installations.

Based on these case studies, innovative solutions for autonomous flight, data acquisition, and their processing for issue recognition and/or the creation of maps and other representations in near real-time will be explored (taking into account constraints related to navigation speed, altitude, accuracy, resolution, etc.)

The research activity will include both phases of searching for innovative solutions supported by simulation and experimental development activities, with extensive data acquisition campaigns in the field made possible by the availability of areas that can be used for this purpose throughout Italy.

Requirements:

Applicants are expected to have strong programming skills (including Python, C/C++), a strong desire to acquire new theoretical knowledge and learn new technologies, and a strong problem-solving aptitude.

References:

[1] Morando L, Recchiuto CT, Calla J, Scuteri P, Sgorbissa A. Thermal and Visual Tracking of Photovoltaic Plants for Autonomous UAV Inspection. *Drones*. 2022; 6(11):347

[2] Zormpas, A.; Moirogiorgou, K.; Kalaitzakis, K.; Plokamakis, G.A.; Partsinevelos, P.; Giakos, G.; Zervakis, M. Power Transmission Lines Inspection using Properly Equipped Unmanned Aerial Vehicle (UAV). In Proceedings of the 2018 IEEE International Conference on Imaging Systems and Techniques (IST), Krakow, Poland, 16–18 October 2018; pp. 1–5.

Company name and link (for industrial projects):

JPDroni s.r.l. – Genova (https://www.jpdroni.it/)

Number of positions available: 1

Main Research Sites DIBRIS Department, RICE lab (Robots and Intelligent systems for Citizens and the Environment), Via Opera Pia 13, Genova, Italy. JPDroni s.r.l. – Genova
Contacts: Email: antonio.sgorbissa@unige.it Email: jacopo.calla@jpdroni.it
Funding Scheme: This doctorate grant is co-funded by Jp Droni and by Regione Liguria.

2. Underwater Inspection and Maintenance with Marine Robots - Università di Genova

Curriculum: Robots and Intelligent Machines for Inspection and Maintenance of Infrastructures

Hosting Institution
University of Genova

Department:
Department of Informatics, Bioengineering, Robotics, and Systems Engineering - DIBRIS

Tutor(s):
Giovanni Indiveri and Enrico Simetti

Description:
Systems composed by heterogeneous robotic platforms are increasingly studied for their use in the marine environment. The robotic team can be composed of underwater vehicles (carrying sensors, e.g., water quality sensors, hydrophones, magnetometers, etc.) and surface vehicles (typically with a support role, for example for the localization of underwater vehicles, or carrying large payloads such as sparkers). In certain cases, an underwater vehicle can be physically connected to a surface through a tether cable, to exploit the extended communication range of the surface vessel, and possibly power from it.
The applications of such systems are diverse, and range from water quality monitoring, to offshore aquaculture inspection, to geotechnical exploration [1]. Among the scenarios, the monitoring and inspection of underwater cables and pipelines with marine robots could drastically reduce costs of the maintenance of offshore wind farms [2]. In the above reference scenarios, different research challenges emerge, including low-level control strategies, reliable navigation and guidance in real-world conditions, limited communication ranges and bandwidths and coordination and distributed task allocation and monitoring.
Within this PhD proposal, we want to investigate the use of such systems focusing on two main aspects. The first deals with the low-level control strategies, reliable navigation and guidance in real-world conditions of each of the team members. The second one relates to the possible integration of acoustic sensor payload modules (eg. multibeam, forward looking, sidescan sonars) and the exploitation of the related acquired data for mission (re)planning.

Requirements:
Very good knowledge of Matlab and C++ is required.

References:

- Simetti, E., Indiveri, G., & Pascoal, A. M. (2021). WiMUST: A cooperative marine robotic system for autonomous geotechnical surveys. Journal of Field Robotics, 38(2), 268-288.
- Campos, D. F., Matos, A., & Pinto, A. M. (2021). Multi-domain inspection of offshore wind farms using an autonomous surface vehicle. SN Applied Sciences, 3(4), 1-19.

Number of positions available:
1

Main Research Site
Department of Informatics, Bioengineering, Robotics, and Systems Engineering - DIBRIS, via all'Opera Pia, 13 - 16145 Genova (ISME node)

Contacts:
Email: giovanni.indiveri@unige.it and enrico.simetti@unige.it

Funding Scheme: This doctorate grant is funded by the proponent research institution.

3. Collaborative and Autonomous object transportation – Italian Institute of Technology

Curriculum: Inspection and maintenance of infrastructures
Hosting Institution Istituto Italiano di Tecnologia
Department: Humanoid and Human Centred Mechatronics Research line (https://hhcm.iit.it/)
Tutor(s): Nikos Tsagarakis (nikos.tsagarakis@iit.it) Luca Muratore (luca.muratote@iit.it) Arturo Laurenzi (arturo.laurenzi@iit.it)
Description: In the last years, there was an increasing use of collaborative robots (cobots) in real applications ranging from industrial to construction. One of the advantages of using these platforms is that they can help humans to perform tasks such as the movement of a big and/or heavy object to a target location, which can be hard and dangerous for a person. The objective of this thesis will be the implementation of a framework to allow the transparent collaboration between a human and the mobile platforms CONCERT and the under development new quadruped platform of HHCM Lab. The CONCERT platform is composed by a customized mobile base equipped with a modular and reconfigurable high payload collaborative manipulation system all developed in HHCM lab within the EU project CONCERT (https://concertproject.eu/) , which targets to explore this platform in task scenarios relevant to the construction application domain. The under development HHCM quadrupedal manipulation platform will be instead explored within industrial settings in maintenance related tasks requiring bi-manual object manipulation/transportation skills. Tasks will include the transportation of large size, rigid objects of varying dimension and weight through paths that may be constrained by environmental entities such as walls in narrow passages or obstacles on the ground. This will involve the development of the following control and interaction components, will permit the robot to: i) sense and interpret the physical interaction with the human though the co-transported object, ii) implement a leader-follower behavior to enable the robot to adjust its pose and mobile base motions based on the interactions perceived through preoperative and visual sensing and iii) autonomously evade the constraints and obstacles in the operating workspace by not only avoiding its own collision with the environment but also by ensuring that the body of the transported item do not collide with the environment. This will be achieved by realizing perception driven autonomous mobility and manipulation maneuvers when passing through constrained passages like corridors and corners, co-carrying the transported item with the human.
Requirements: This topic lies in the intersection of motion and navigation planning. Ideal applicants should have strong C++ and Python programming competences. A background in any of Robotics, Computer/Robotic Vision, Path Planning, and Robot Learning is desirable, while knowledge of the Robot Operating System (ROS) is a plus. The applicants should be fluent in English and team players.
References:

- D. J. Agravante, A. Cherubini, A. Bussy, P. Gergondet, and A. Kheddar, “Collaborative human-humanoid carrying using vision and haptic sensing,” in Proc. IEEE Int. Conf. Robot. Autom. (ICRA), May 2014, pp. 607–612.
- D. Sirintuna, A. Giammarino and A. Ajoudani, An Object Deformation-Agnostic Framework for Human–Robot Collaborative Transportation, IEEE Trans. on Automation Science and Engineering, 2023

Number of positions available: 1

Main Research Site
Istituto Italiano di Tecnologia, Center for Robotics and Intelligent Systems, Genova

Contacts:
Email: Nikos.tsagarakis@iit.it

Funding Scheme: This doctorate positions is funded by a commercial/research project.

4. Locomotion planning and control of a hybrid legged/wheeled quadruped – Italian Institute of Technology

Curriculum: **Inspection and maintenance of infrastructures**

Hosting Institution
Istituto Italiano di Tecnologia

Department:
Humanoid and Human Centred Mechatronics Research line (https://hhcm.iit.it/)

Tutor(s):
Nikos Tsagarakis (nikos.tsagarakis@iit.it)
Luca Rossini (luca.rossini@iit.it)
Arturo Laurenzi (arturo.laurenzi@iit.it)

Description:
Emerging robots operating within man-made real-word workspaces will have to walk, reach, physically interact, pick up, retrieve and manipulate a variety of objects, tools and interfaces designed for human use. This research theme will focus on the development of hybrid locomotion planning strategies for the existing CENTAURO robot, which is equipped with wheeled and legged mobility (https://www.youtube.com/watch?v=F8F7aOxqZ6Y&t=13s, https://www.iit.it/web/humanoids-human-centered-mechatronics/robot-control) as well the new version of the platform that will be available during the duration of the PhD study. On flat terrains directly driven wheels will move the robot quickly and efficiently in an omnidirectional way by independently adjusting their speed and orientation. When driving over uneven ground, the legs will adapt to the surface, such that the posture of the main body is stabilized. Different principles and combinations of leg gaits and wheel mobility mechanisms will be developed and evaluated in simulation and finally implemented and validated on the CENTAURO prototype and the under development new quadrupedal manipulation platform of HHCM lab.

Requirements:
We are seeking for highly motivated candidates with a background in Electrical, Mechanical or Control engineering, Physical Sciences or Robotics. Candidates should have strong competencies in robot dynamics, control and excellent programming skills in C++. (Programing and Simulation 30%, Dynamics/Control %70). The experience on dynamic simulators (e.g. Gazebo) and ROS would be plus. The applicants should be fluent in English and team players.

References:

- De Luca A, Muratore L, Tsagarakis N.G., A Hybrid Primitive-Based Navigation Planner for the Wheeled-Legged Robot CENTAURO, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp7904-7911, 2022.
- Ferrari P., Rossini l., Ruscelli R., Laurenzi A., Oriolo G., Tsagarakis N.G., Mingo Hoffman E., Multi-contact planning and control for humanoid robots: Design and validation of a complete framework, Robotics and Autonomous Systems, 2023.
- Laurenzi A., Mingo Hoffman E., Tsagarakis N. G., Quadrupedal walking motion and footstep placement through linear model predictive control, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp 2267-2273, 2018.

Number of positions available: 1

Main Research Site
Istituto Italiano di Tecnologia, Center for Robotics and Intelligent Systems, Genova

Contacts:

Email: Nikos.tsagarakis@iit.it
Funding Scheme: This doctorate positions is funded by a commercial/research project IIT.